Article

Cultures of Science

Cultures of Science
Vol. 3 Issue 1-2, June 2020 1–10

DOI: 10.1177/2096608320917579
journals.sagepub.com/home/cul
SAGE

After Joseph Needham: The legacy reviewed, the agenda revised – some personal reflections

Geoffrey Lloyd
The Needham Research Institute, UK

Abstract

We all owe Joseph Needham an immense debt for discovering Chinese science and technology for Western scholars. But his famous question (Why did the Chinese, who had been so far in advance of Europe until the 17th century, fail to produce modern science independently?) is simplistic.

- Needham's discussion relied on categories ('physics', 'engineering', even 'mathematics') that are largely anachronistic.
- He was preoccupied by questions of priorities (who did what first).
- We should recognise that the historical record brings to light many breakthroughs in the development of science, in Egypt, Mesopotamia, India, ancient Greece and ancient China, as well as in Europe in the 17th century and beyond; they all call for detailed analysis of the different social, political, economic, institutional and intellectual factors at work.
- One topic of particular importance and current interest concerns the factors that enable innovation to flourish, where the differing experience of ancient societies can provide lessons that may still be relevant today. The new agenda for the history of science should have a global remit.

Keywords

Joseph Needham, science, China, the West

For Western scholars, Joseph Needham founded a subject – the comparative history of science and technology. No one before him had even begun fully to appreciate China's contribution. I had the privilege and honour to have many conversations with him, especially when – after unsuccessfully approaching some five or six other individuals – he finally turned to me to succeed Lord Roll as Chair of the East Asian History of Science Trust, the body responsible for overseeing the work of the Needham Research Institute (NRI). Even though I was sixth or seventh choice for the job (I was and am no captain of industry, after all, which was really what he was looking for), and although at the time most thought the NRI was moribund (some were already writing its obituary), I was very happy to do what I could to resuscitate it. Restoring it from intensive care in the late 1980s to its present state of moderately rude health took determination and teamwork – the collaboration of individuals with very

Corresponding author:
Geoffrey Lloyd, Needham Research Institute, 8 Sylvester Road, Cambridge CB3 9AF, UK.
Email: gel20@cam.ac.uk

different backgrounds and interests, some based here in Cambridge, others across the world. It would be invidious to try to name them all, though we all shared a devotion to the Great Man. For my part, I made it my business to discuss at length with Joseph the future of the NRI and the prospects for the history and philosophy of science in general; we did so many times in his declining years.

My acquaintance with Joseph goes back to the 1960s. My first contact with him was when I received one of his famous index cards, which posed the question: 'When was the first Greek or Roman diving bell?' This came with the instruction to reply on the card itself, which was to be returned to Joseph. I believe he approached me because his usual adviser on Graeco-Roman matters, Arthur Peck, was on sabbatical at Princeton, and Peck knew that I was one of the very few people in Cambridge at the time with any interest in Greek science, medicine and technology. But I was in luck with that question, for the answer concerning the first extant evidence of a Greek diving bell is clear: it comes in the text called the *Problemata*, Book 32, Chapter 5, which describes how divers use cauldrons which retain the air inside them, provided they are maintained in a vertical position. The *Problemata* is a text in the Aristotelian Corpus, but not by Aristotle but by one of Aristotle's pupils, and it mostly dates to the late 4th or 3rd century BCE. *Voilà*. Problem solved.

Then, when I was Senior Tutor at King's College in the turbulent days of the late 1960s and early 1970s, I saw Joseph as an important and prestigious ally in the furore that raged about student representation on college councils and faculty boards, the sit-in in the Senate House, and the protests at the Garden House Hotel in 1970 when it was used to promote Greek products and so to support the dictatorial rule of the Greek colonels.[1] He was kind enough to give me and my colleagues great moral support in our attempts to calm things down, but he explained that he could not actively engage in the work of the committees set up to consider various aspects of university reform. Why? Because *Science and Civilisation in China* (*SCC*) took precedence. Absolutely right. Nevertheless, he came to my rooms at King's several times to discuss the problems – always clandestinely: I was sworn to keep those visits confidential. All a touch reminiscent of the cloak-and-dagger intrigues of the Warring States, but without the daggers.

The multiple volumes of *SCC* are truly monumental. Yet the plan and execution are, as we all know, very much of their time, and this has certainly contributed to its relative lack of influence in history and philosophy of science circles in the West – in contrast to the continuing mass of attention it still attracts in China itself. Joseph decided to organise the work according to Western categories: astronomy, mathematics, physics, engineering, medicine and so on. He was convinced not just that science is now universal but that those disciplinary boundaries can be used in relation to the science of much earlier times, where he had, of course, quite a preoccupation with who made which discovery first (by the time *SCC* 7.2 was published in 2004, the list of Chinese 'firsts' had grown to more than 250; it did not, incidentally, contain any mention of a diving bell). He famously and repeatedly depicted the contributions of different ancient traditions as a plurality of different streams and rivers all eventually converging in the great ocean of today's unified science.

But over and above the distractions of that question of priorities, there are two main problems with that way of organising the material. First, as Joseph well knew, the ancient Chinese themselves did not have exactly (in some cases not even approximately) the same concepts as ours of the disciplines in which they engaged or of the boundaries between them. We may have little difficulty identifying what we call Chinese 'medicine', but even there we must be careful not to assume that what counted as 'health' or 'well-being' for them in any given period is what we may count as such (and that is problematic too if we stop to think about it, not just in terms of the tricky issues involved in 'mental health').

Second, the Chinese in premodern times did not have our modern Western concepts of the causes of disease (pathogens) and how to combat them – and I have no need to remind you that our thinking on those subjects had a long struggle to emancipate itself from the legacy of Graeco-Roman, Islamic and medieval notions. Nor do you need reminding of the ongoing controversies, in China and elsewhere, of the status and viability of so-called 'alternative' medicine, where it is important, in my view, not to

lump together all the practices associated with traditional Chinese medicine (TCM) to attempt some overall verdict on its validity, however much some practitioners of biomedicine, and indeed some of TCM, may urge us to do so. Not all of TCM is as straightforwardly efficacious as the traditional use of a species of artemisia (*qinghao*) as a treatment for malaria.

Again, although some scholars have proposed that Chinese studies of the heavens, *tian wen* (the patterns in the heavens) and *li fa* (calendar studies) are roughly equivalent to the contrast we draw between astrology and astronomy, that is highly problematic. The 'patterns' are not investigated just to yield predictions for events on earth, and while calendar studies certainly apply mathematics and in that resemble our astronomy, they do not extend to geometrical models of heavenly movements or other aspects of astronomical theory as it has been practised in the West. So *tian wen* and *li fa* do not map at all happily onto 'astrology' and 'astronomy', any more than do Greek *astrologia* and *astronomia*. Yet the Greeks could and did distinguish between (a) predictions of heavenly movements and (b) predictions about events on earth on that basis, even if those two Greek terms can also be used interchangeably.

Analogously, any attempt to find a single Chinese category that corresponds to our 'physics' is bound to force all sorts of issues (where again exactly the same point applies to the ancient Greeks). In practice, of course, what came to be included in the several volumes of *SCC* that were labelled 'Physics' covered a multitude of different fields of research and practice, both theoretical and practical; and the same was true of the various sections devoted to 'Chemistry'.

This question of the original indigenous Chinese conceptual categories is no mere quibble. The issue that *SCC* tended to finesse but which has to be pressed is this: if we cannot, on pain of anachronism, use our modern categories, then we have to ask what the Chinese researchers themselves thought they were doing, and why. What did they imagine to be the pay-off? How did their work reflect on or interact with the values of the society in which they lived? They could not have entertained the ambition to become 'scientists', for no such category existed – indeed, it emerged in the West only in the 19th century.

Thus, we face an apparent gap in our grasp of what may have motivated those investigators who made such important contributions to an understanding of the world around them. Nor should we imagine that the answer to those questions is uniform in every period and across all the fields that interested them, such as the heavens (the movements of the sun and moon, and solar and lunar eclipses), the calendar, music, the body, health and disease, plants and animals, change and transformation, to mention just a few examples. This point about heterogeneity is crucial (and I shall return to it) as it concerns not just China but also ancient Greece and other ancient societies, as well as modern science.

So, my first issue with the organisation and structure of *SCC* relates to indigenous category boundaries. But my second problem follows on from the first. Needham's perspective was resolutely teleological: he looked at China and other ancient societies from the point of view of the eventual development of science as we know it today, and it was that breakthrough in the 17th century, the so-called Scientific Revolution, that inspired his big question – why it happened in the West and not in China. But if we adopt the perspective of the ancient investigators themselves, we get a very different and more fundamental agenda. We can identify many different contributions to an understanding of the world from China and other ancient civilisations: Egypt, Mesopotamia, Greece, India, Islam and Mesoamerica. But why are there such divergences in what our records offer? What does the complex and varied history of the development of inquiry in ancient civilisations tell us about human cognitive development in general? We should not limit ourselves to China and the West, nor indeed to ancient literate civilisations, though I know I shall be considered foolhardy for proposing that further extension of the agenda.

Yet, after all, we all came out of Africa, even though that has often been caricatured. True, the question of when and where those movements occurred continues to be fiercely debated. There is general agreement that the break with our nearest relatives among the hominids happened at some specifiable time and place. But if all humans share a common

origin (if you go back far enough) and if there are powerful commonalities in what humans strive to make sense of, such as the environment, plants and animals, life and death, then why historical human struggles for understanding have been so diverse is a question that may seem crushingly naive but cannot be ignored. After all, if we accept Joseph's image of the common global ocean of modern scientific understanding, why that needed to be fed by such a multitude of different streams and rivers (let alone a few stagnant pools) is a question that does not go away. Starting with ancient China and ancient Greece, we can open up questions about human endeavours to understand the world more generally, although we should not assume that those endeavours all reflect the same ambitions, or even the same conception of what 'the world' comprises, let alone the same social, institutional and intellectual circumstances.

Of course, widely differing types of explanatory factors have been invoked in grand global theories to account for what happened. Some fancy physical differences, others social or economic ones, and yet others factors to do with language and literacy. I will say something about each of these, just to give a sense of how the diversity of human efforts to understand the world has been tackled and with such shockingly limited results.

To a small degree, differences in understandings can be explained by differences in what there was to be understood: the physical environment, for example, the flora and the fauna, of different parts of the earth. You cannot expect humans to be concerned with the structure of a snowflake if they have no acquaintance with snow. Over and over again, some classification of plants that was presumed comprehensive has had to be upended following the discovery of previously unknown kinds. That was more a problem in the West than in China, given the West's greater pretensions to produce a universal system of plant taxonomy – a far less prominent preoccupation for Li Shizhen in the 16th century. In point of fact, it only gradually dawned on European botanical taxonomists north of the Alps that much of what they found in the texts of their main authorities, the Greek botanists Theophrastus and Dioscorides,[2] related to species limited to the Mediterranean area and, conversely, that some northern European species did not figure in those compendia.

Again, there are also important differences between the various primary modes of subsistence that humans have relied on, as between hunter-gatherers, herders and farmers. We now have a much firmer grasp of the major changes that occurred at different times and places, and of the shifts and transitions in theoretical and practical knowledge as various areas of technology came to be developed, in agriculture, textiles, metallurgy, water management, urbanisation and so on. Much of the latest knowledge comes from research undertaken at the NRI or by scholars associated with it, inspired by Professor Mei Jianjun. This helps us a little to understand the nature of progress in human knowledge and its uneven tenor in different societies, but much remains unexplained.

Joseph himself pinned his hopes on a combination of economic and political factors, adapting the Marxian notion of differences in the modes of production and the role of 'bureaucratic feudalism'. But, as many commentators have observed, most pointedly perhaps Mark Elvin in his contribution to *SCC* 7.2 (Elvin, 2004), that combination is a fairly crude tool to discriminate between China and Europe, and it has the signal disadvantage of implying a static economic and social regime in China down the ages. True, throughout pre-revolutionary China the political ideal remained the benevolent rule of a sage king, but ideas and practices about how to achieve this varied greatly. In his final summary of his views in *SCC* 7.2 – where he reprints some of his earlier essays, mostly with very little modification – Joseph wrote extensively on the rise of the bourgeoisie in the West, leading to the growth of capitalism, the scientific method and the industrial revolution 'one after another'.[3] But again, as he half admitted, that was subject to severe qualifications as a global explanatory factor.

Indeed, none of the available considerations I have mentioned so far is really fit for the heavy-duty work of explanation that Joseph was looking for in relation to his question, let alone for the further issues raised by the immense variety of actual ways of being in the world and of attempting to understand it, to which the historical and ethnographic records give us access.

But what about what have sometimes been thought to be the more promising differences, in the

technology of communication, in language itself and in degrees of literacy associated with different modes of writing (a favourite with Jack Goody (1977) and indeed a factor that Joseph targeted, though not in relation to him (Needham, 2004a: 230f.)? This too is a topic where the waters have been much muddied by some highly superficial speculations, and I do not just mean the common accusation often voiced by those with no firsthand knowledge of Chinese: namely, that it is a hopelessly ambiguous language. Sometimes that view is a grotesquely extravagant inference from the comparative lack of morphology in Chinese, but more often it just stems from downright prejudice. Ancient and modern Chinese writers and thinkers were and are usually perfectly capable of expressing whatever they want to express, and with the degree of precision they think appropriate. For sure, there are numerous ambiguities in the classical texts, but ambiguity can be useful: it leaves open a range of interpretations that wait to be explored. Indeed, in classical Chinese rhetoric this is often a deliberate, quite cunning ploy that is exploited to excellent effect.

At one stage it was proposed that the Chinese language does not countenance counterfactual conditionals, and that was imagined to be crucially relevant to the development of 'science', given its heavy dependence on exploring counterfactual hypotheses.[4] Yet it did not take long for that to be exposed as a gross mistake. From the earliest times, Chinese writers contemplated counter-to-fact situations – there are some fine examples in the 2nd century BCE compendium *Huainanzi* and even earlier in the 4th–3rd century BCE texts of the *Gongsun Longzi*.[5] There is even a linguistic form that marks these out, *jiashi*, which is roughly translatable as 'falsely supposing' (see Harbsmeier, 1998: 117). The *shi* corresponds to 'if' but the qualifying *jia* indicates that this is counterfactual. Nothing could be a clearer counterfactual than Gongsun Long's 'if there were no things within the world'.

We can and should concede that the range of different modes of conditionality that are expressible in a highly inflected language such as ancient Greek can be conveyed only by paraphrase or elaboration in a language such as classical Chinese. Yet, as my colleague Robert Wardy showed rather conclusively, when they were faced with the problem of translating the Latin versions of Aristotle's texts in the 16th and 17th centuries, the Chinese certainly did not find that impossible (Wardy, 2000). In fact, their performance was comparable to that of Latin translators when they faced the equivalent task of rendering his Greek into their Latin.

As for the second factor that linguistic determinists are prone to cite, namely, the effects of literacy on the rise of a critical and sceptical spirit, I can be brief, for two reasons. The first is that written texts, especially when treated as canonical, let alone sacred, can stifle criticism, not foster it. Second, literacy as such does not, of course, discriminate between quite a few different ancient civilisations across the Eurasian landmass (see Lloyd, 2014: 116–139).

My all-too-rapid critique of just some of the factors invoked to account for the different trajectories of modes of thought and inquiry in premodern societies should not be taken to imply that I dismiss them all out of hand. As I said, we can see the limited relevance of different items – physical, economic, social, institutional, intellectual – at different junctures. But what none of them singly, nor the whole gamut collectively, provides is the makings of a grand global history of those trajectories. In particular, they do not enable us to answer Needham's question of why modern science did not occur independently in China. Indeed, with no single overall explanation coming near to commanding anything like a consensus – despite the very considerable efforts expended over the past 50 years or so – we might conclude that the question as posed is incapable of resolution.

The conclusion looms that what Joseph continued to be preoccupied with was really an unanswerable question to which he failed to find a fully satisfactory solution. At points in his contributions to *SCC* 7.2, he effectively admits that definitive answers are not, as yet, forthcoming.[6] Yet what we can take away from his monumental research is not a simple – oversimple and ill-formed – particular problem, but a wealth of detailed data offering marvellous possible areas for investigating the complex factors at work at different points in the diverse endeavours that different individuals and groups made to understand the

world around them – whatever they took that to be, and indeed, different views were entertained on that subject.

This is where a new agenda begins to emerge from the ashes of the old. We should not think that their notions of how to go about understanding, and even what understanding entails, were all the same. Indeed, the evidence shows that they had many different goals – a point that applies not just within ancient China but also within and between ancient Greece, Egypt, Mesopotamia and India. Heterogeneity again.

So what I propose as an alternative to the Needham question starts by problematizing what 'science' itself can be taken to include. We are used to thinking of it as a well-defined endeavour, unified by a single determinate 'scientific method'. Joseph himself focused on 'mathematised hypotheses' combined with 'relentless experimentation'.[7] But this is yet another oversimplification. A case can be made, as I have detailed elsewhere (Lloyd, 2009: 153–171), that science just calls on a particular systematisation of cognitive capacities that we all possess, at least potentially. One can, in fact, find both experiment and the application of mathematics to understanding physical phenomena in both ancient China, for example, in the *Zhoubi Suanjing* at the turn of the millennium, and ancient Greece. Systematic observation differs from merely looking and seeing but can be said to be continuous with the latter. Controlled experiment owes much to ordinary trial-and-error methods, and deductive argument is just a tidier and more self-conscious version of common-or-garden arguing and inferring. I have accordingly defended the view that to seek the origin or origins of 'science' itself may be misleading. The simple but crucial point is that different areas of scientific endeavour draw on different techniques – and that is still true today. In some areas, such as the exploration of distant galaxies, direct experiment is neither necessary nor even possible. But all that variety tends to be brushed aside when we attempt to encapsulate exactly what 'the' scientific method comprises, armed with which some set out to judge both the West and China as if each was a determinate monolithic entity.

Until such time as we can produce a satisfactory account of what 'the' 'modern' scientific method consists in, we shall not be able to identify what was 'missing' in China or in any other ancient or modern society which we tend to regard as 'pre-scientific'. So on the view I would favour, the way to tackle the Needham question is to unravel it. We would not then face what is supposed to be a single massive – but quite unmanageable – problem that lumps together everything that went into 'the' 'Scientific Revolution' and demands that we satisfy ourselves on the character of 'the' 'scientific method' that brought 'it' about in the West but failed to do so in China or anywhere else. Rather, we would have a whole series of very difficult but more focused issues, concerning details of the inquiries undertaken at any one period or in any civilisation. Although China and the West have dominated scholarly attention, other ancient societies (and indeed modern ones, as revealed by ethnography) are not only interesting in their own right but can also be used to test hypotheses we might propose on the relative importance of different factors at different junctures in the development of systematic investigations.

So the Needham question as traditionally conceived looks all too seductively simple yet is anything but. In fact, I believe it turns out to be an obstacle insofar as it tends to distract attention from where the real work lies – investigating the activities and achievements of different individuals and groups in the particular complex situations in which they worked, on which, of course, Needham has masses of important comments to make in the many thousands of pages of *SCC*. But there were many crucial turning-points in the history of the development of science, and they all deserve our attention.[8] To call them 'Revolutions' dramatises them, but none was a well-defined historical event like the Storming of the Bastille or of the Winter Palace.

Besides, those major scientific changes occurred at different times and places depending on the science we are discussing. In the study of the heavens, the regularities in planetary motion were first discovered in Babylonia in the 8th century BCE (see Rochberg, 2016). With that major breakthrough, the reappearance of a planet after a period of invisibility became predictable. Then my colleague Nathan Sivin in a famous article (Sivin, 1995 [1982]) pointed first to the work of the astronomer and polymath Shen

Gua in the 11th century and then identified a revolution carried out by the mathematician Mei Wending and his associates in the 17th century.[9] Meanwhile, in my own work (e.g. Lloyd, 2002) I have discussed at length what different ancient Greeks managed or did not manage in different fields at different periods, and not just Aristotle proving the earth's sphericity and cutting up octopuses to investigate their reproductive system, Archimedes in his bath, and Aristarchus failing to persuade his contemporaries that heliocentricity was the answer (to which I will shortly return). In every case we need to identify the specificities of the social, political, institutional and intellectual circumstances in which individuals or groups worked and allow the diversity in the answers to those questions, not just as between Archimedes and Shen Gua and Copernicus but also between Copernicus and Galileo and Kepler and Harvey and Newton. They were all great investigators, for sure, but the ways they were great differed.

I repeat that these are difficult questions, but one topic where I think we can make some progress concerning the conditions of possibility for innovation, where the different trajectories of science in the ancient Graeco-Roman and Chinese worlds may even have some relevance for the situation we all face today. Let me end with some observations on that, focusing particularly on the study of the heavens.

The issue turns on the question of state support in ancient and modern scientific research. In astronomy, especially, the contrast between Mesopotamia and China on the one hand and Greece on the other is striking. In the first two civilisations, astronomy was an affair of state, but Greek astronomers were very much on their own. Two ingenious characters called Eudoxus and Callippus were responsible for excellent work on determining the length of the tropical year in the 4th century BCE. But they held no official position, and their results were only half-heartedly implemented even in the city-state where they lived (Athens). This contrasts starkly with China, where already in the Han dynasty there were officials supported by the State who were responsible for astronomical observations, foreshadowing the later Astronomical Bureau which in Ming times offered employment to literally hundreds of researchers.

The advantages and disadvantages of the two kinds of set-up – strong state support and its complete absence – are (I suggest) mirror images of one another. With state support, the astronomers in Mesopotamia and China had to work to the state's agenda, but they had regular employment and, in China especially, teams of assistants. With no such help or recognition, the Greeks had far more freedom to propose their own agenda, but had to earn a living as best they could – mostly by casting horoscopes. The main alternative was teaching or lecturing; their exhibition lectures, called *epideixeis*, served as publicity to attract customers to undertake and pay for the more extensive and expensive courses they offered.

Naturally, in such circumstances, the ambition was to produce startlingly original ideas, which I hold to be one reason why they are so common in ancient Greek thought in general. Among the crazy ideas the astronomers came up with was the highly counterintuitive hypothesis that the earth moves round the sun. Aristarchus was the first to propose that, but even before him, in the 5th century BCE, the Pythagorean Philolaus had suggested that the earth is just another planet, moving not round the sun but what he called the Central Fire. But look what happened. Heliocentricity was rejected in ancient Greece, not because it offended the authorities (as in the days of Galileo) but because the ancient astronomers themselves could not accept it. If the earth rotated on its axis once every 24 hours (a necessary assumption for the hypothesis to work), that could be expected to have dramatic effects on the earth's atmosphere. Clouds or missiles – that is, javelins or bolts hurled by catapults – could never move eastwards (Ptolemy said in the 2nd century CE)[10] because they would always be overtaken by the movement of the earth itself.

Of course, the understanding of physical phenomena was in its very early days in both ancient China and ancient Greece, but the tension between orthodoxy and innovation has remained a problem ever since. With today's massive support for science across the world, there is every chance that any decent new idea will be taken up and developed. After all, the ambition to succeed, to make a name for oneself, to win that coveted Nobel Prize, is as

strong now as it ever was. (Competition still drives innovation, as does necessity if one thinks of the threat to the world's ecology.) But three points give cause for concern.

First, today's scientists must prove themselves masters of what passes as received wisdom, jumping successfully through the hoops of BA, MA and PhD degrees and post-doc positions. It is dangerous to display too much originality too soon in your career, as that may not be recognised and you may find yourself marked down. Without a straight-A record, how will you be accepted by your preferred graduate school? Recall that both Darwin and Einstein had very undistinguished undergraduate careers. Indeed, Darwin had not long graduated from Cambridge with an ordinary degree (he did not even take honours) when he embarked on his extraordinary voyage of discovery on the *Beagle*. How many nowadays could live that poor academic record down to go on to do brilliant research?

Second, the major innovations of 20th-century science were not accepted with open arms. I lived through both the plate tectonic and DNA discoveries in Cambridge; in both cases, the principal proponents were initially treated with suspicion, even hostility, and their scientific credentials were called into question. When Crick was proposed for a fellowship in my own College (I was at King's at the time), the Provost consulted the current leading biochemists and was told that Crick's ideas were a flash in the pan and that in a month or two nothing more would be heard of them.

Third, what gets taken up and sponsored reflects commercial and military interests as often as it does the disinterested pursuit of the truth. In all of this, I think we still have much to learn from both the ancient Chinese and Greek models; from their contrasting strengths and corresponding weaknesses. There are clear advantages to massive state support for science (as in ancient China) but also disadvantages in outside influences (whether governmental or commercial) on the agenda. Conversely, in ancient Greece, individuals were free to go it alone, but then they had to, since there were no state institutions to back them up. In particular, we moderns, in both China and the West, have to continue to worry about striking the right balance between state support and the individual's freedom of manoeuvre, particularly in relation to scientific research that raises acute moral problems. You should not think that this is an exclusively modern phenomenon – the pros and cons of stem-cell research certainly are, but already in Greek antiquity the practice of human vivisection for medical research raised an outcry, in some quarters at least.

Let me return to the main point and recapitulate. I started with the problems I have with Joseph's anachronisms, his teleology and his preoccupation with the supposedly key event of the 17th-century scientific revolution in the West that did not happen in China. We should, I suggest, widen our remit to include the history of human attempts to understand the world and their experience of it more generally (which would allow me to discuss the full range of ancient Greek achievements). When we thus broaden the agenda, we encounter many limited breakthroughs across different cultures and periods. I cast doubt on grand theories of the trajectory of human endeavours in general, but ended with some very summary remarks on one topic where some progress in our understanding of the impact of different institutional regimes seems possible, namely in the study of the conditions of possibility for innovation, where we are still faced, today, with finding a balance between individual freedom of manoeuvre and corporate or state support.

Those who yearn for a single definitive answer to what they imagined to be the simple Needham question will, no doubt, be taken aback at my twin insistences on complexity and specificity, and I certainly concede that it is harder work.[11] But it should release us from any idea that we should focus more or less exclusively on that one supposedly simple explanandum when we have so much other work to do to investigate the shifting fortunes of scientific investigation down the ages. That hard work chimes, however, with the ambitious plans being entertained by the new Director of a revived NRI, where enthusiastic young scholars drawn from many different countries and with many different skills and interests are engaged in inspiring studies of a considerable variety of topics, involving increasingly significant collaborations with different faculties and institutions in the university, including the faculties of Asian and

Middle Eastern Studies, History and Philosophy of Science, Archaeology, Classics, Social Anthropology and CRASSH (the Centre for Research in the Arts, Social Sciences and Humanities), to name but six.

For me, revising the agenda means being prepared to look closely at all the complexity and specificity I mentioned – the work of famous individuals and of anonymous craftsmen. But reviewing the legacy means continuing the investigations that Needham launched, not in precisely the way he organised them but recognisably in line with the spirit that animated his work, insofar as he set a shining example of the most profound cross-cultural and interdisciplinary investigation of human endeavours to comprehend the world.

Acknowledgements

This is a slightly modified version of the first Needham Memorial Lecture that I delivered on 28 October 2016. I am most grateful to the sponsors, Jing Brand Co. Ltd, and also to Professor Roel Sterckx and Clare College for hosting the event. My thanks also go to John Moffett and Jenny Zhao for their help in preparing the lecture.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Notes

1. This led to the arrest of 15 students, who were tried at the Hertfordshire assizes. Eight of them were sentenced to between 9 and 18 months in prison.
2. Theophrastus' great botanical treatises date from the 4th century BCE. Dioscorides' *De Materia Medica* was written in the 1st century CE.
3. 'It is the rise of the bourgeoisie in Western Europe from the 15th century onwards which decided that Europe . . . would strike out in a new direction, developing capitalism, scientific method and the industrial revolution one after another' (Needham, 2004a: 229).
4. See Bloom (1981), extensively criticised by Harbsmeier (1998: 116ff.).
5. 'Supposing that within the world there were no pointing out of things, what would we have the opportunity to call *not* the pointed-out? If within the world there were no things, what would we have the opportunity to call the pointed-out?' (Gongsun Long, *Zhiwu lun*, discussed by Graham, 1989: 91–94).
6. 'In sum, I believe that the analysable differences in social and economic pattern between China and Western Europe will in the end illuminate *as far as anything can ever throw light on it*, both the earlier predominance of Chinese science and technology and also the later rise of science in Europe alone' (Needham, 2004b: 23, italics added). He later added that such questions as 'why did the Roman Empire fall?' are stimulating . . . but 'they have no definitive answers' (Needham, 2004a: 231).
7. 'If I were asked to define modern science, I would say that it is the combination of mathematised hypotheses about natural phenomena with relentless experimentation' (Needham, 2004b: 1 note 2).
8. Important pre-modern 'breakthroughs':

   Babylonia 8th century BCE: Recognition of the regularities in planetary movements and predictions of visibility/invisibility.

   Greece:
   Philolaus (proposed non-geocentric system) 5th century BCE
   Eudoxus (concentric spheres hypothesis) c. 365 BCE
   Callippus (modified Eudoxus) c. 330 BCE
   Aristotle 384–322 BCE (proves sphericity of earth)
   Aristarchus of Samos (heliocentricity) c. 275 BCE
   Archimedes 287–212 BCE

   China:
   Huainanzi (compendium of knowledge) 139 BCE
   Zhoubi suanjing (cosmology and cosmography) c. 50 CE
   Shen Gua (astronomer and polymath) 978–1052 CE
   Li Shizhen (plants/pharmacopoeia) 1518–1598 CE
   Mei Wending (mathematician and astronomer) 1632–1721 CE
9. 'In two decades of study, teaching and public lecturing on Chinese science and medicine, I have encountered no question more often than why modern science did not develop independently in China, and none on which more firmly based opinions have been formed on the basis of less critical attention to available evidence' (Sivin, 1995 [1982]: 46).
10. Ptolemy, *Syntaxis* (otherwise known as the *Almagest*). See Heiberg (1898), Book 1, ch. 7, p. 24.
11. Arguments very similar to mine have subsequently been advanced by contributors to the issue of *ISIS* (an international review devoted to the history of

science and its cultural influence) (101.1, Spring 2019) devoted to a 'second look' at Needham's legacy. On the one hand, it is agreed that the framework within which to carry out our investigations needs to be modified to avoid the pitfalls of anachronism and of treating either 'China' or 'the West' as homogeneous entities. On the other hand, this does not mean we should abandon Needham's ambition to engage in deep comparative studies to elucidate specificities of the developments in different places and times in human endeavours to understand the world.

References

Bloom A (1981) *The Linguistic Shaping of Thought: A Study in the Impact of Language on Thinking in China and the West*. Hillsdale, NJ: Lawrence Erlbaum.

Elvin M (2004) Vale atque Ave. In: Robinson KG (ed.) *Science and Civilisation in China*, vol. 7, part 2. Cambridge: Cambridge University Press, pp. xxiv–xliii.

Goody J (1977) *The Domestication of the Savage Mind*. Cambridge: Cambridge University Press.

Graham AC (1989) *Disputers of the Tao*. La Salle, IL: Open Court.

Harbsmeier C (1998) *Science and Civilisation in China*, vol. 7, part 1, Language and Logic. Cambridge: Cambridge University Press.

Heiberg IL (1898) *Claudii Ptolemaei opera quae exstant omnia*, vol. 1. Leipzig: Teubneri.

Lloyd GER (2002) *The Ambitions of Curiosity*. Cambridge: Cambridge University Press.

Lloyd GER (2009) *Disciplines in the Making*. Oxford: Oxford University Press.

Lloyd GER (2014) *The Ideals of Inquiry*. Oxford: Oxford University Press.

Needham J (2004a) Modern science: Why from Europe? In: Robinson KG (ed.) *Science and Civilisation in China*, vol. 7, part 2. Cambridge: Cambridge University Press, pp. 224–231.

Needham J (2004b) Science and society in East and West. In: Robinson KG (ed.) *Science and Civilisation in China*, vol. 7, part 2. Cambridge: Cambridge University Press, pp. 1–23.

Rochberg F (2016) *Before Nature: Cuneiform Knowledge and the History of Science*. Chicago, IL: University of Chicago Press.

Sivin N (1995 [1982]) Why the scientific revolution did not take place in China – or didn't it? (originally *Chinese Science*, 1982, 5: 45–66). In: Sivin N (ed.) *Science in Ancient China: Researches and Reflections*. Aldershot: Variorum.

Wardy RBB (2000) *Aristotle in China: Language, Categories and Translation*. Cambridge: Cambridge University Press.

Author biography

Geoffrey Lloyd is Emeritus Professor of Ancient Philosophy and Science at the University of Cambridge, where from 1989 to 2000 he was Master of Darwin College. He has been a Trustee of the NRI from 1991 and he was Chair of the trust from 1992 to 2002. He has held Visiting Professorships in North and South America, in Europe, in the Far East and Australia and holds Honorary Doctorates from Athens, Oxford and St Andrews. He is the author of 23 books, most recently *The Ambivalences of Rationality: Ancient and Modern Cross-Cultural Explorations* (Cambridge: Cambridge University Press, 2018), and he has edited a further seven. He has been a Fellow of the Royal Anthropological Society since 1970, of the British Academy since 1983, and of the American Academy of Arts and Sciences since 1995. He was awarded the Sarton Medal in 1987, the Kenyon Medal in 2007, the Dan David Prize in 2013 and the Fyssen Prize in 2014. He was knighted for 'services to the history of thought' in 1997.